IEA Bioenergy
Technology Collaboration Programme

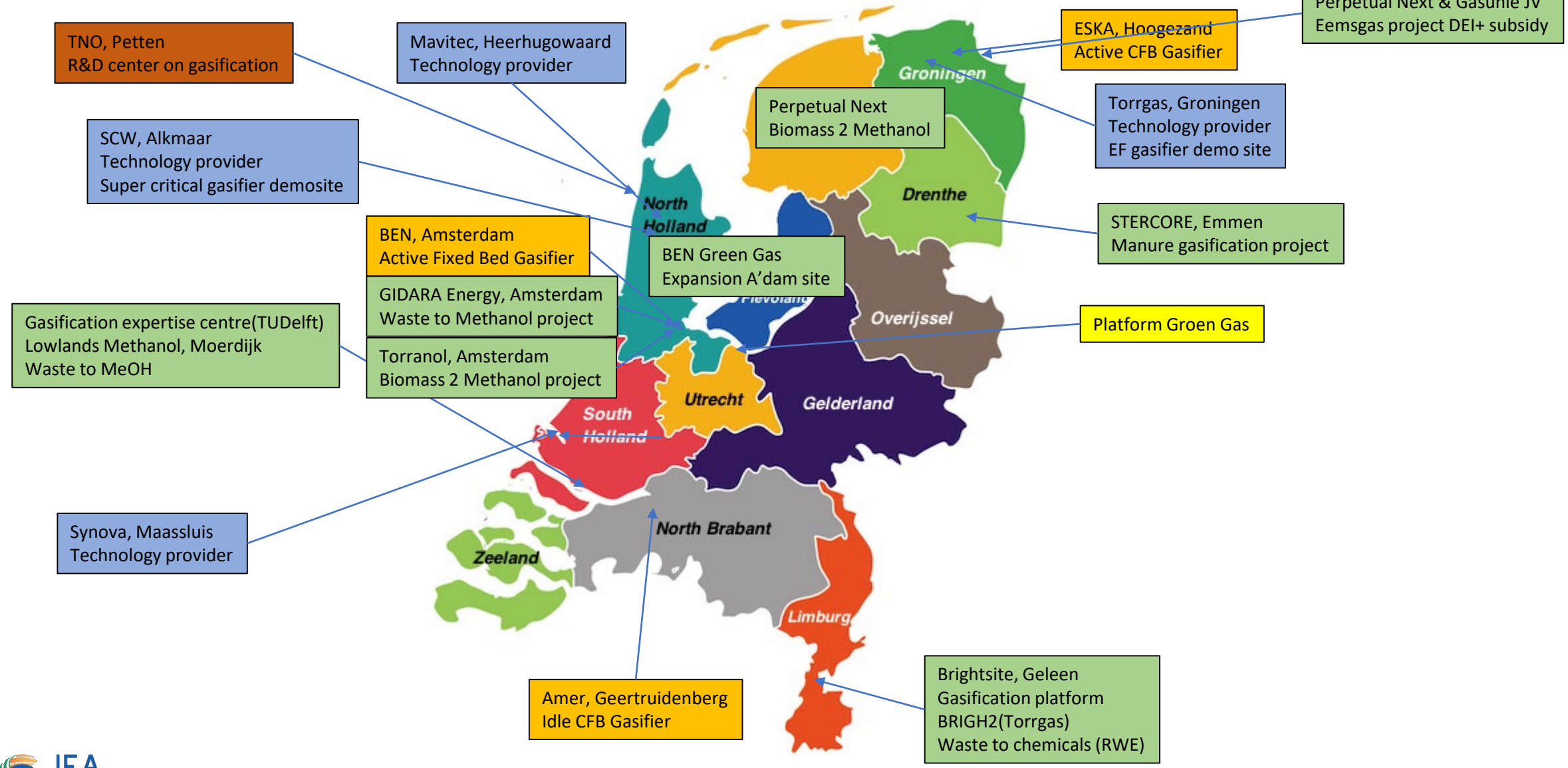
Task 33 Country report The Netherlands

June 2026

Berend Vreugdenhil

Glasgow

Gasification activities in the Netherlands

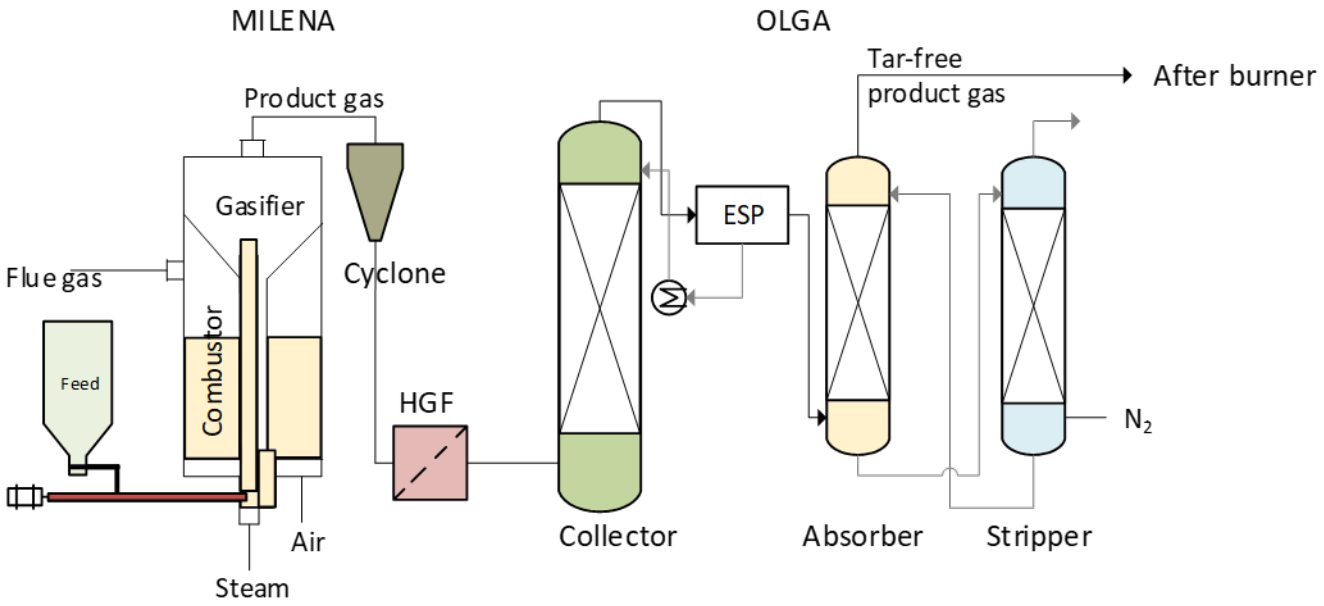


Dutch Blending Mandate

- Starting data is now 1-1-2027
- 25% reduction on the original goals
- Roughly 2,8 Mton of CO2 reduction in 2030
- Equivalent of 1 – 1,1 bcm of green gas by 2030
- Failure to comply can be fixed with a buy-out of ~450 euro/ton or 0,85 euro/m3 green gas

- EemsGas = Perpetual Next and Gasunie developing a 30 MWth plant based on TNO technology

TNO – Indirect Gasification



Platform Technology MILENA-OLGA

- Developed for Green Gas production, aiming to demonstrate
- HEU Butterfly project on production of Methane and DME from indirect gasification
- Platform further developed to recycle complex waste streams
- Project SAGITTARIUS on the production of MeOH just granted

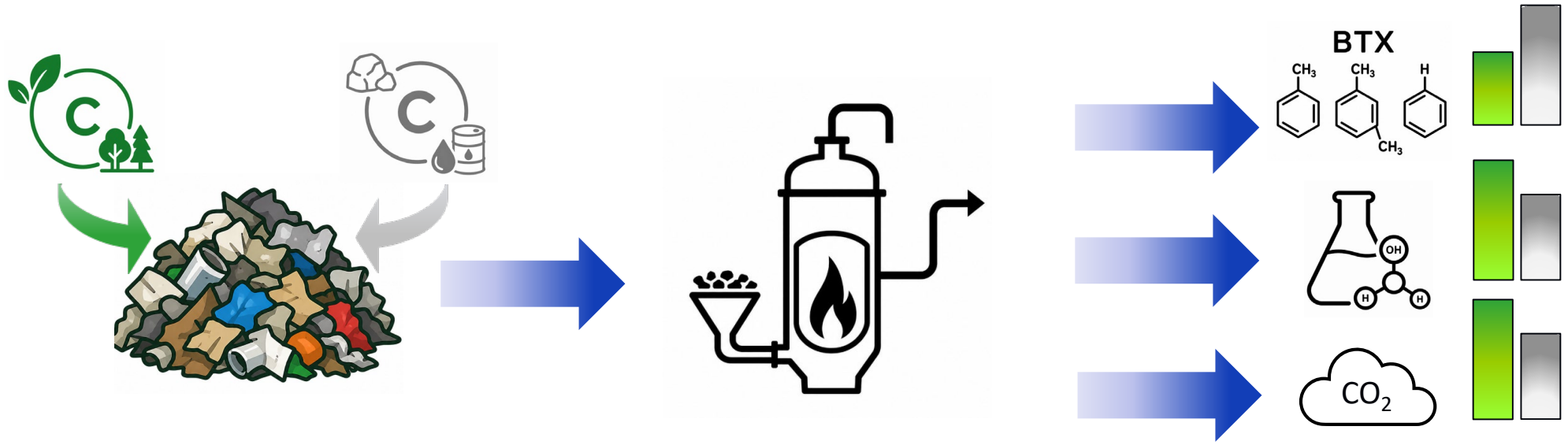
Results from SAGITTARIUS -Aim and approach

Aims

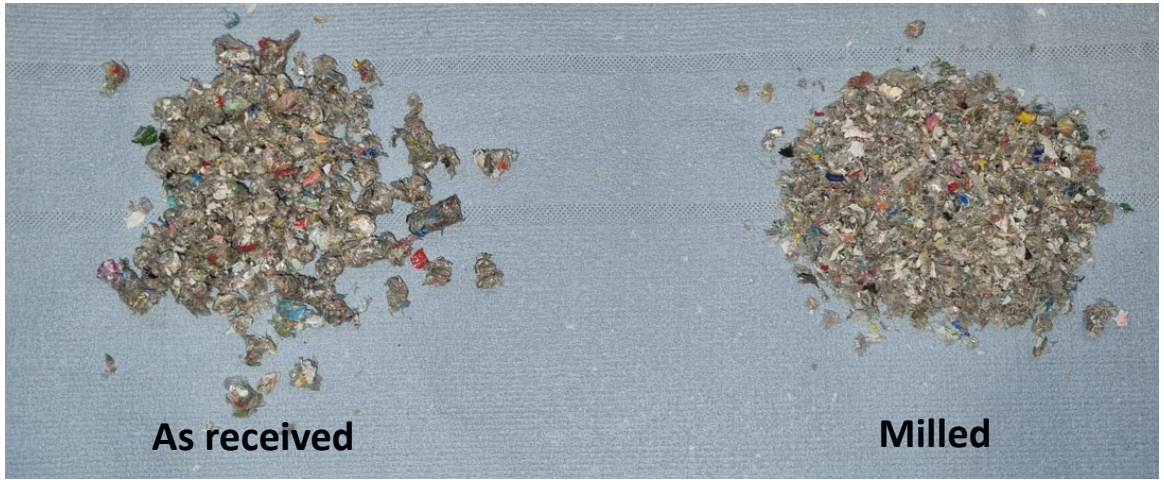
- The work aims to gain insight into the distribution of biogenic and fossil-based carbon across the feedstock and products namely BTX, methanol and CO_2.

Approach

- Indirect gasification tests with two RDF feedstocks, followed by gas cleaning and upgrading.
- Collect BTX and methanol samples, and CO_2 in the product gas ➔ analyse with feedstock for biogenic carbon content



Feedstocks



Two feedstocks

- RDF 1: Mixed waste
- RDF 2: Plastic-rich waste

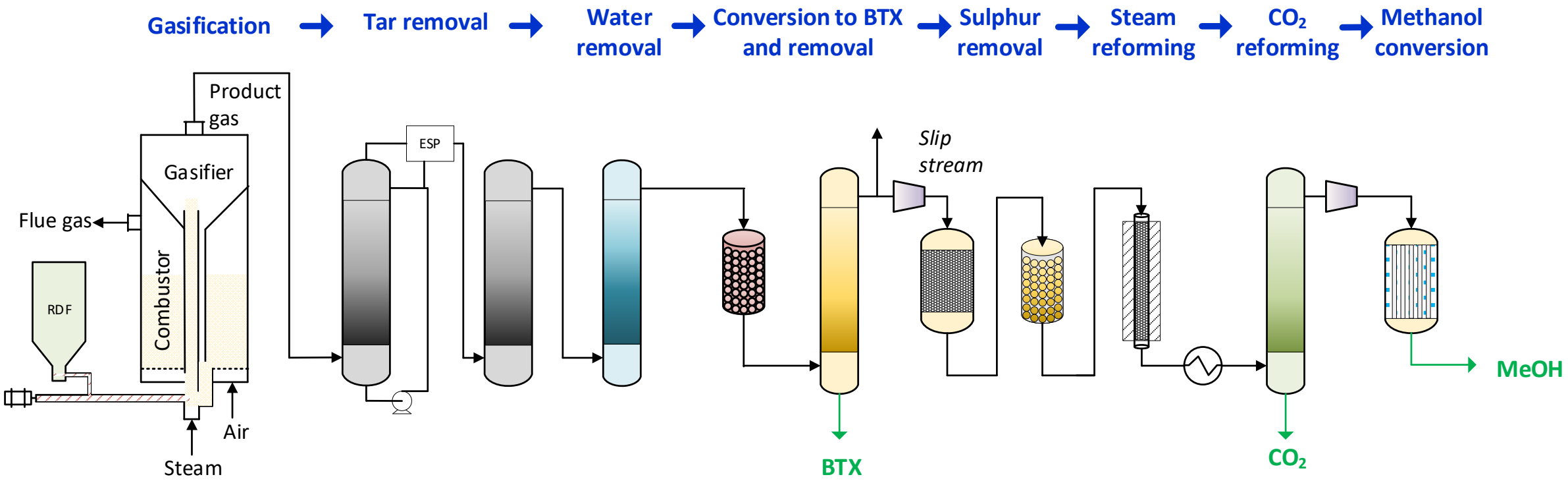
Analysis results

		RDF 1	RDF 2
Moisture	wt.%	3.8	4.0
Ash	wt.% (db)	20.3	14.0
Volatiles	wt.% (db)	70.3	76.1
C	wt.% (db)	51.0	55.5
H	wt.% (db)	6.9	7.1
N	wt.% (db)	0.51	0.79
O	wt.% (db)	23.5	23.7
S	wt.% (db)	0.12	0.28
Cl	wt.% (db)	0.80	1.2
Biogenic carbon[a]	%	**37.0**	**27.4**

[a] Biogenic carbon/total carbon

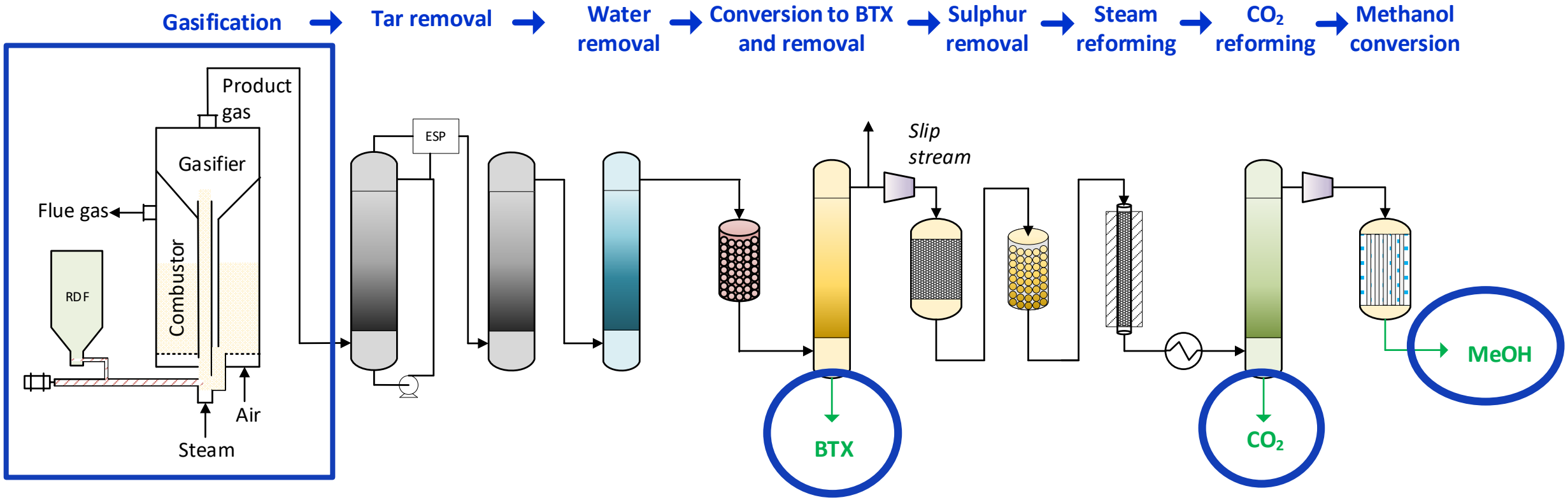
Feedstock provided by N+P Group (Subcoal)

Experimental line-up



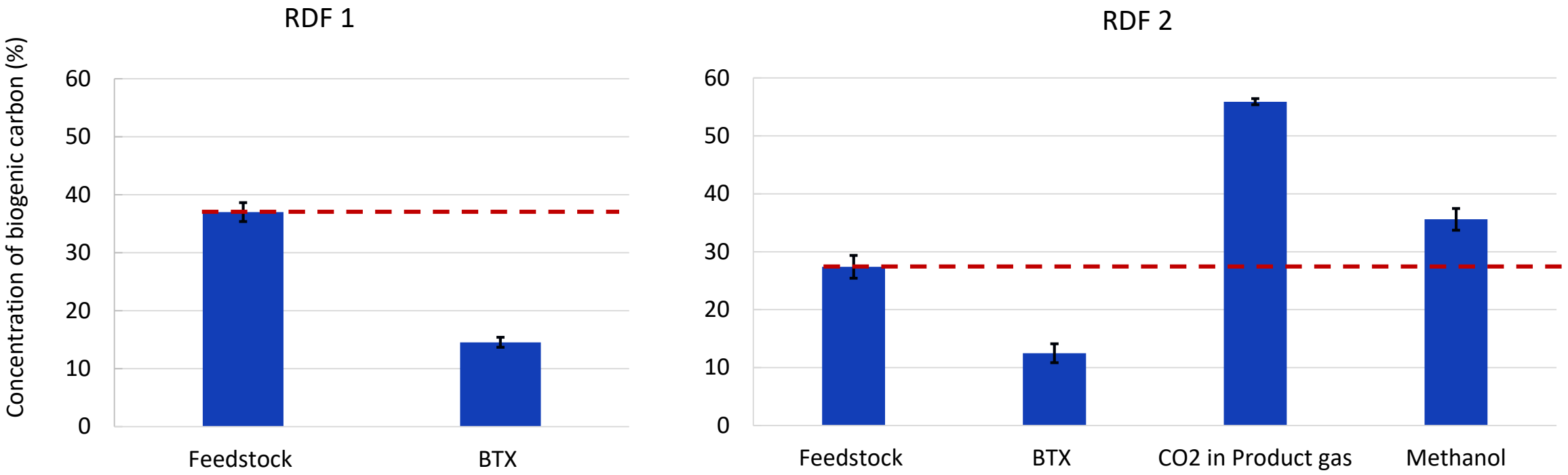
- Gasification and fuels upgrading lab in Petten
- Complete gasification to methanol train with co-production of BTX.
- Capacity is 5 $kg_{feedstock}/h$ produces 3 Nm^3/g of gas

Experimental line-up



Gasification temperature	**750 – 760 °C**
Steam-to-carbon ratio	**1.0 g/g**
Feed rate of RDF	**4.5 kg/h**

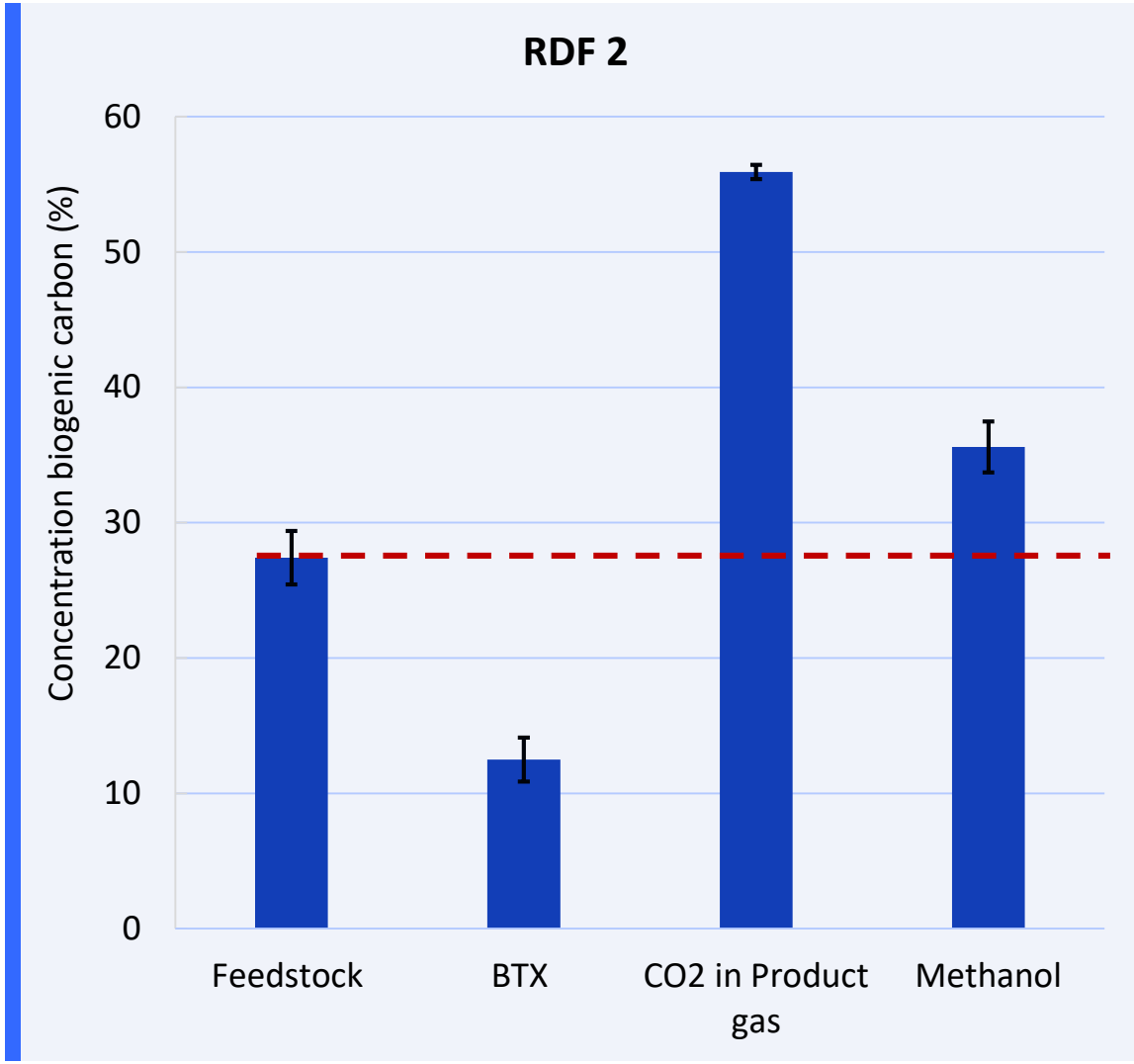
Distribution of biogenic carbon



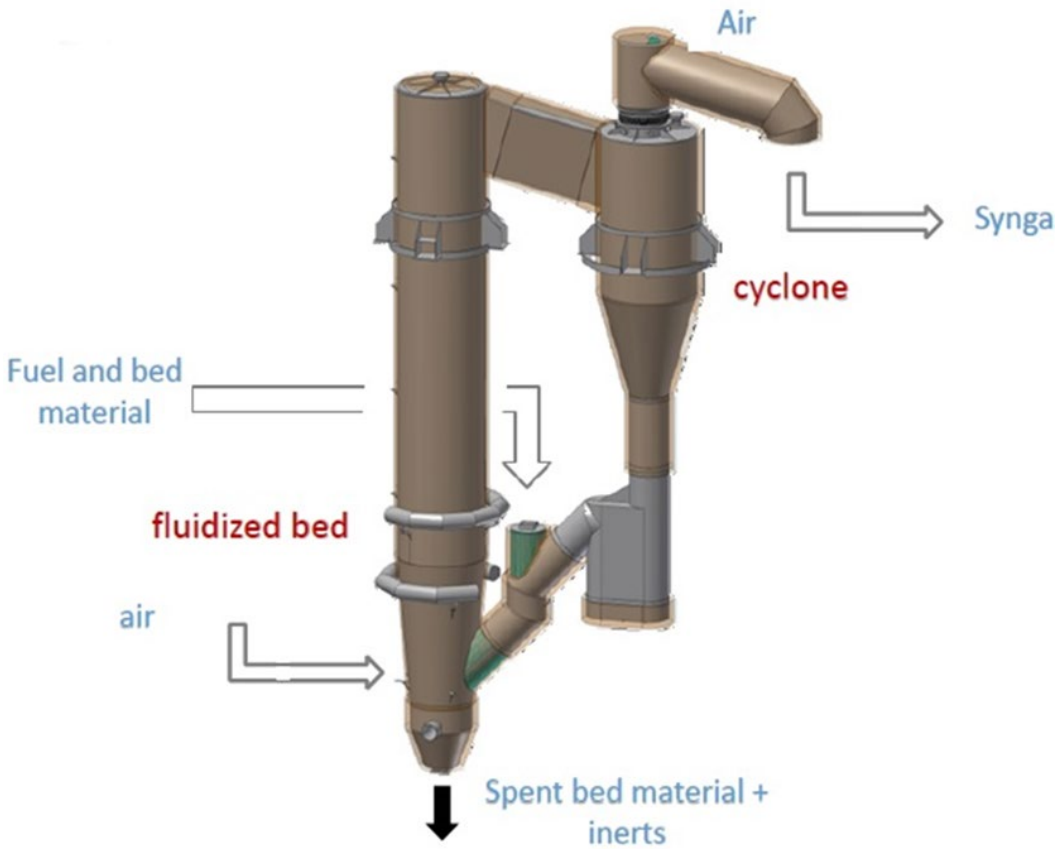
- Error bars show standard deviation in the measurement.
- For RDF 1 the process only ran till the BTX collection step.

Distribution of biogenic carbon

- **BTX is enriched with fossil-based carbon:**
  - Plastics yield aromatics either directly (PET, PS) or via C_2-C_3 olefins (PP, PE).
  - Biomass yields comparatively lower aromatics.
- **CO_2 in the product gas is enriched with biogenic carbon:**
  - Biomass produces CO_2, as it is more oxygen-rich compared to plastics.
  - Plastics such as PET also produce CO_2 but are present in lower quantities.
- **Methanol is enriched with biogenic carbon:**
  - Biomass mainly yields syngas which is converted to methanol.



ESKA – CFB gasifier on paper rejects

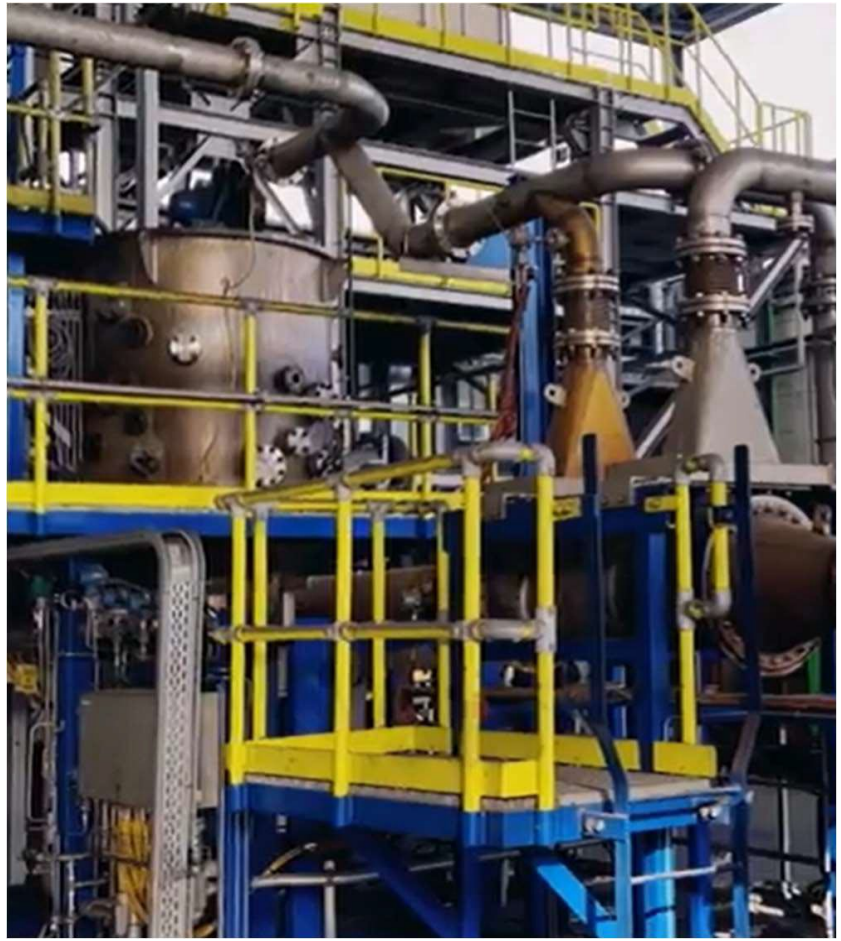


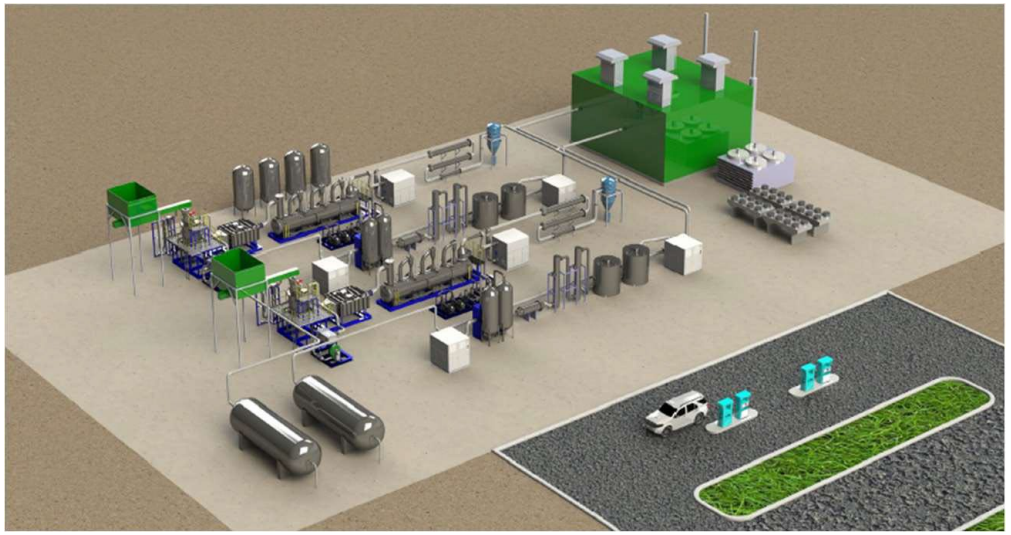
- CFB technology supplied by Leroux & Lotz (TPS technology)
- 10 - 13 MWth input CFB gasifier, depending on LHV rejects
- Boiler produces 5 – 16 ton/h steam (196°C, 13,6 barg)
- Fully automatic operation
- Build in 2016, in operation since Oct-2016

Stil in operation

STERCORE – Manure gasification to Green Gas / Char

BEN – Moving bed gasifiers





Working towards SNG production using fixed bed gasification trains.

Also developing H_2 pathways, CDR options becoming increasingly relevant. Both for char as well as CO_2

Updates GIDARA

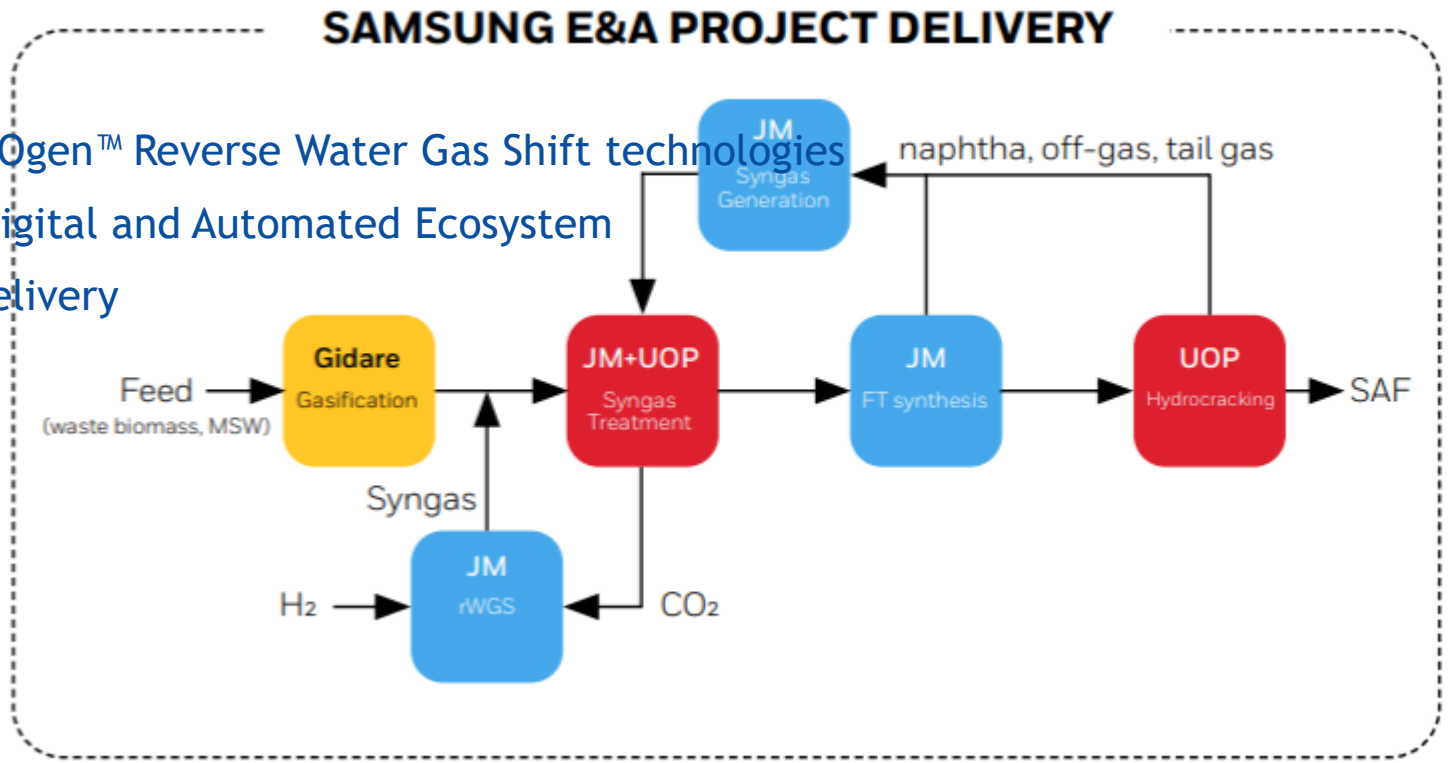
- GIDARA Energy joined SAF Technolgy Alliance

The SAF Technology Alliance introduces a non-exclusive offering designed for customers wanting a full-service delivery to transform waste feedstocks into sustainable aviation fuel. Our vision is to empower fuel producers with accessible, scalable and efficient solutions that harness the untapped potential of waste materials, converting them into SAF.

The joint initiative creates an end-to-end SAF solution, from feed to fuel, leveraging the collective strengths

of each entity:

- GIDARA Energy HTW® Gasification Process
- Johnson Matthey brings FT CANS™ and HyCOgen™ Reverse Water Gas Shift technologies
- Honeywell UOP FT Unicracking™ and HPS Digital and Automated Ecosystem
- Samsung E&A world-class AHEAD Project Delivery



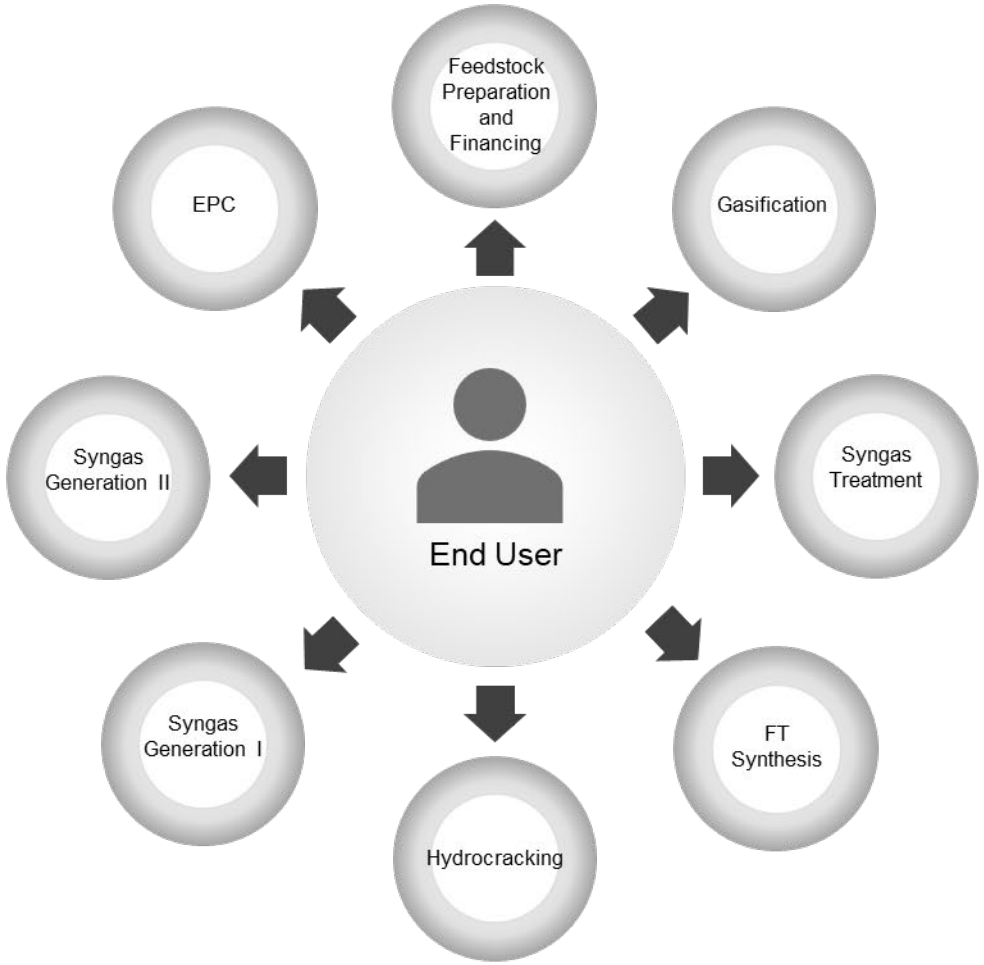
IEA Bioenergy

SAF Technology Alliance

Bankable	Backed by financially stable and reputable collaborators, increasing investor confidence
Integrated Process	All components of the Sustainable Aviation Fuel (SAF) production process are interconnected for optimal performance
Technically Differentiated	Supports large-scale operations with fewer units reducing complexity and maintenance
Operational Benefits	One entity oversees the entire project lifecycle – from design to commissioning – ensuring streamlined communication and decision making
Faster Time to Market	Optimized workflows and modular techniques shorten the time from concept to operation
Financial Benefits	Integrated solutions can reduce time from feasibility study to facility startup by more than 15%, and result in a 5-10% capital cost savings*

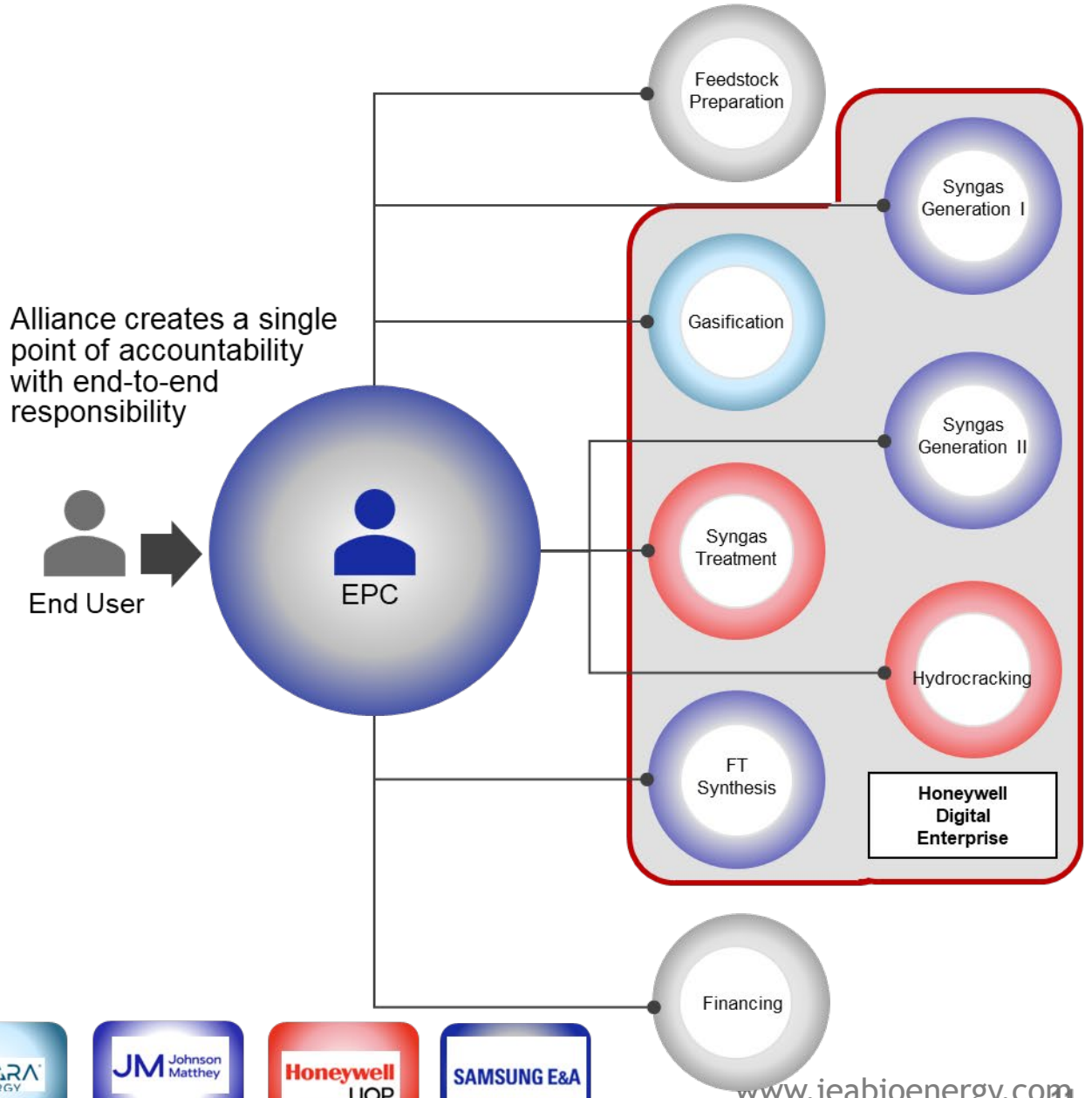
* Based on theoretical schedule and cost analysis when the modularization solution is applied in EPC stage. Schedule analysis based on industry standard benchmarks for project schedule outcomes. Cost comparison is against an open ITB and using standard industry practice upside technology integration.

TYPICAL ENGAGEMENT MODEL



FT Complexes typically requires multiple entities with multiple agreements

ALLIANCE ENGAGEMENT MODEL



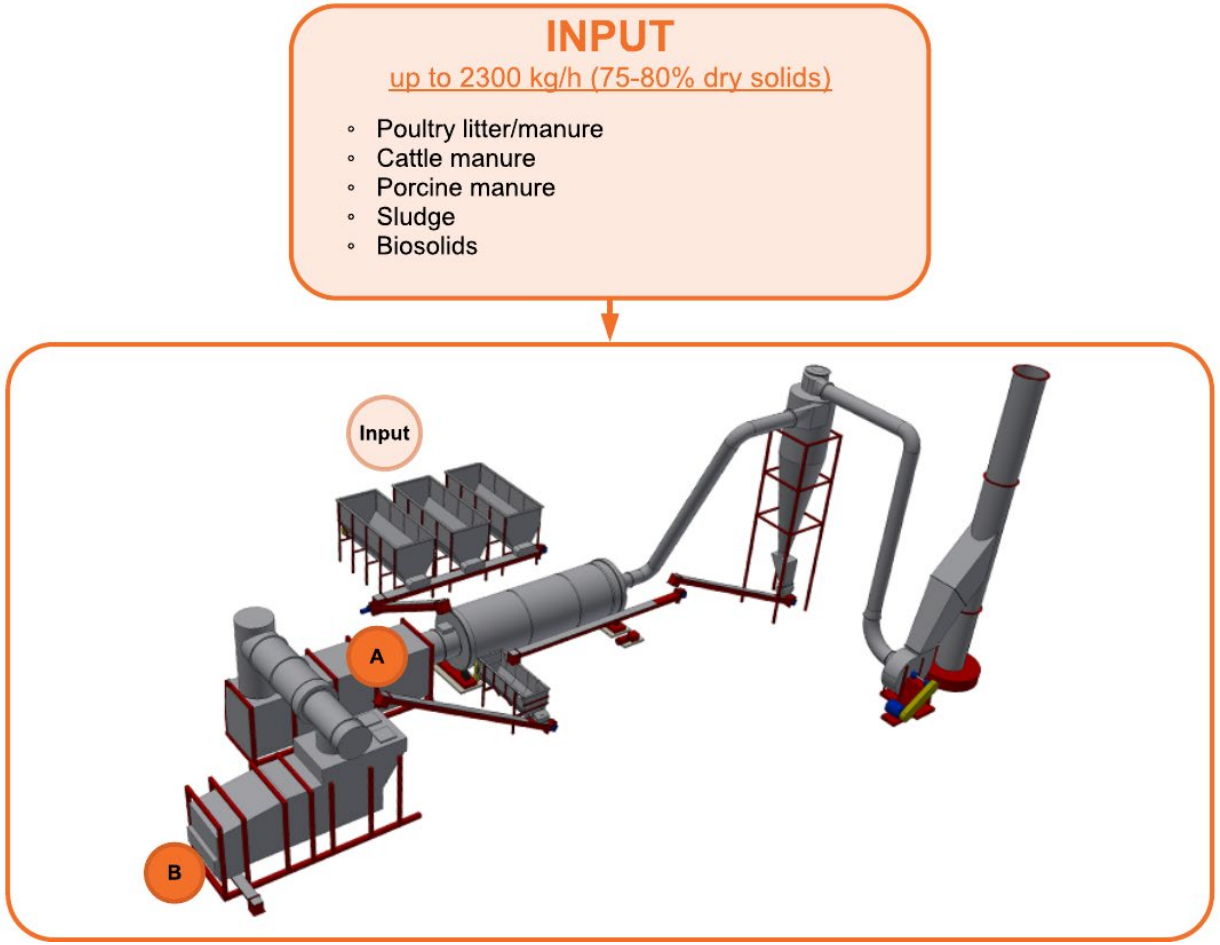
GIDARA ENERGY · JM Johnson Matthey · Honeywell UOP · SAMSUNG E&A

MAVITEC Environmental

Gasification typically to produce steam

- Manure
- Sludge
- Biosolids

Operate globally, not in the Netherlands



HoSt - CFB gasification technology

Involved in HyFuelup in Portugal, providing the back-end solution to turn raw gas into synthesis gas.

A new gasifier has been build and expected start-up is early 2027

HoSt is developing solutions related to gasification, related to the scale of CFB:

- POx reactor for removal of tar, combined in a syngas cooler
- Oxygen facility based on VPSA
- MeOH synthesis

HoSt - Developments (POx reactor)

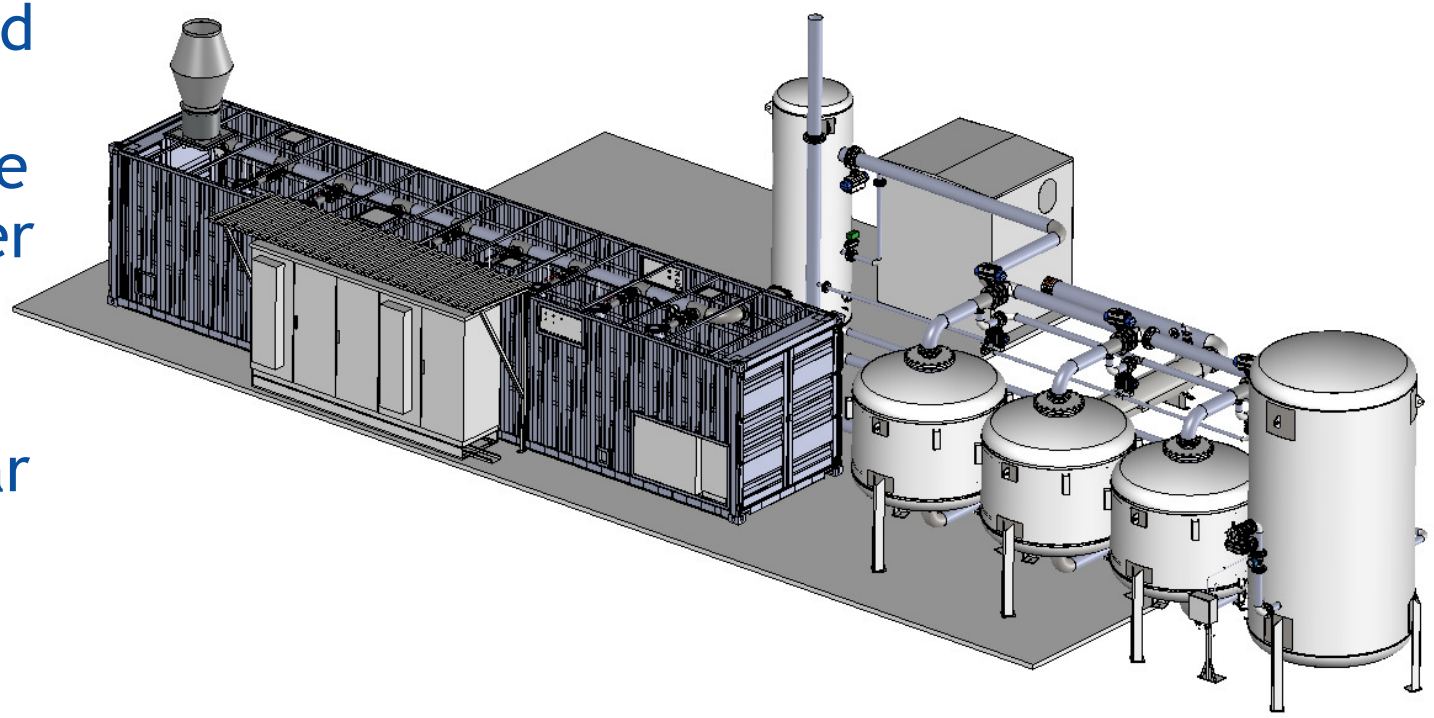
patent pending

HoSt Thermal Technology (part of HoSt group) has developed and built a tar cracker (POX) combined with syngas cooler and steam generator (patent pending), using subsidy from RVO. The reactor will be demonstrated end of 2026, beginning of 2027 in a steam+O2 CFB gasifier (5MWth). The objective is to reduce the tar content up to 97-99%, cool syngas and produce steam at the same time.

HoSt - Other developments VPSA

Hygear (part of HoSt group) has developed a VPSA O2 factory, designed and manufactured in Europe, able to produce up to 600 Nm3/h, 96%O2, for the gasifier and tar cracker. Plant will also be commissioned in 2026, at the same time as the tar cracker and gasifier

HoSt Thermal Technology has also developed technology to feed steam and O2 in its gasifier and tar cracker, improving on its existing gasification technology, to be adapted for fuel synthesis



HoSt – Other developments MeOH synthesis

Bright (part of HoSt group) is developing methanol synthesis technology and will demonstrate it in Sweden next year, for a scale similar to the one for the tar cracker (500kg/h MeOH). This is done through EMPHATICAL project.

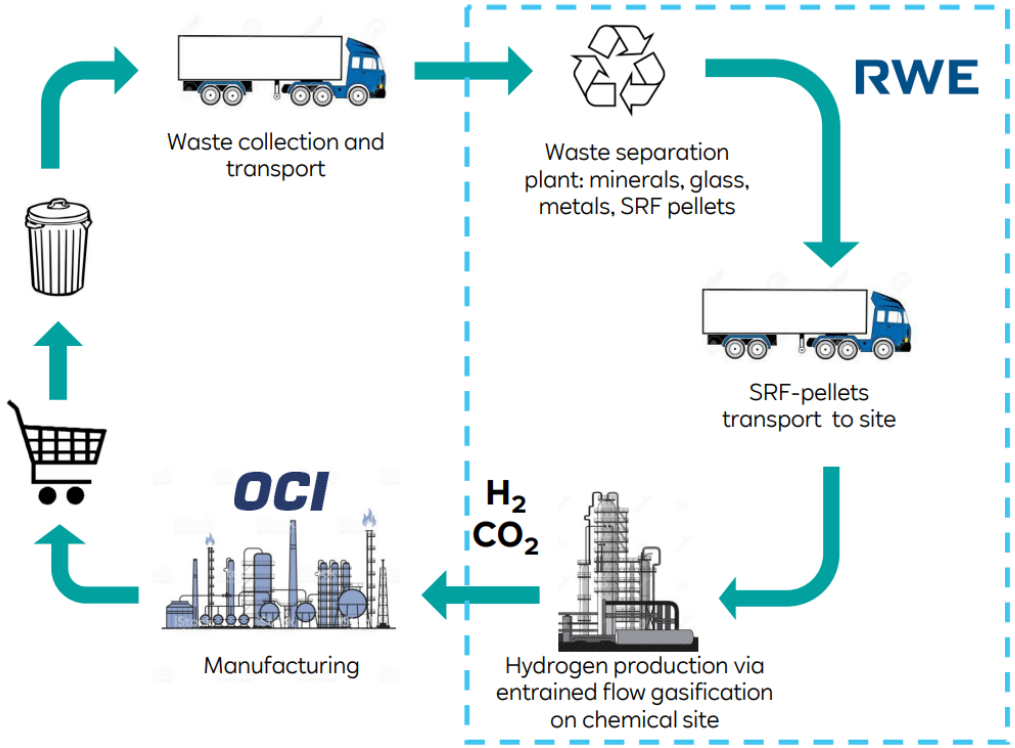
TNO is coordinator of this project: https://www.emphatical.eu/

Commissioning will be in Q2 27, and first operation is slotted for Q3

Furec - RWE

Waste-to-hydrogen produces green and circular hydrogen

Contributing to Project FUREC („Fuse Reuse Recycle")



PROJECT furec

Project typicals

- Processing of Municipal Solid Waste and dried sewage sludge (700.000 t/a)
- Production of hydrogen (≈50.000 t/a)
- CO_2 reduction:
  - 475.000 t/a @ 0 kg/MWh Power
  - 330.000 t/a @ 180 kg/MWh Power
- 800.000 t/a of CO_2 pure, ready for CCS/CCU
- Estimated investment: >500 M€
- Other positive value products: minerals / glass / metals / slag / sulfur / salt
- Commissioning: 2026

Technical work has finished.
-RDF torrefaction technology
-Milling torrefied RDF
-Gasification tests
-Gas cleanup validated

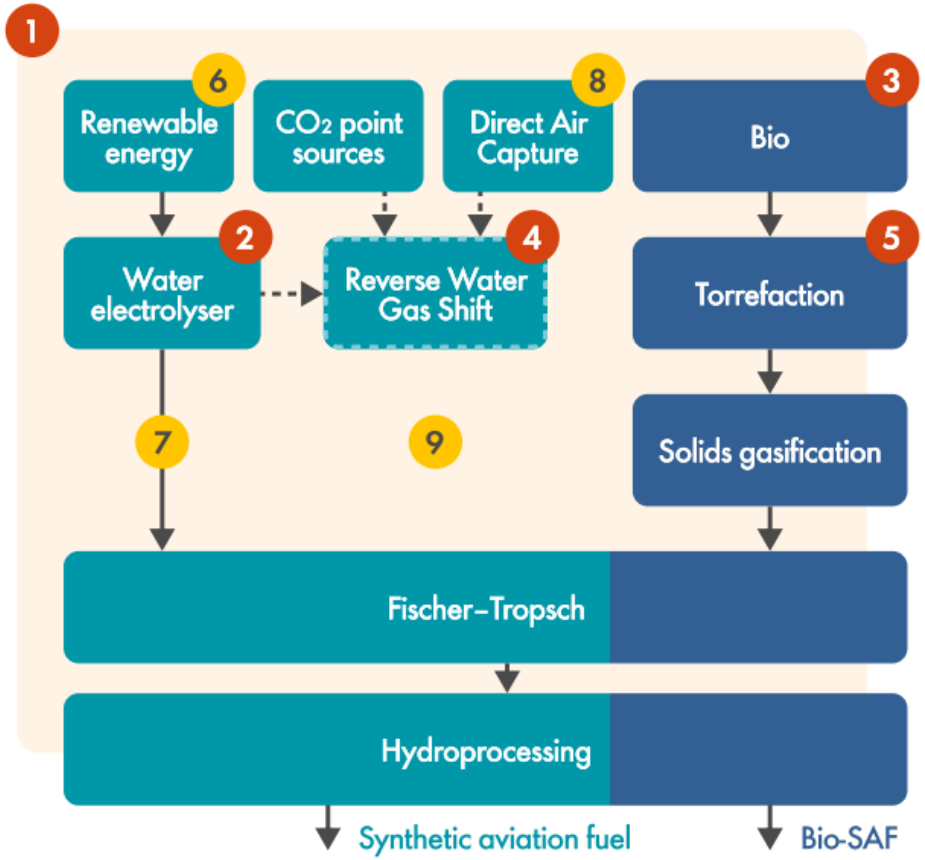
Proceeding to Basic Engineering, but

- No guarantees on hydrogen off-take due to the decline in the EU industrial sector (hard times)
- RWE is still enthusiastic about this technology but is first evaluating if a combination or full MeOH plant would work.
- Based on this assessment the project will continue, but with a delay (permits etc.)

Shell - XtL

Key enablers for first projects

1. Clear requirements from regulators and customers (power, CO_2, sustainable bio-feedstocks)
2. Water electrolyser available at scale and low cost
3. Affordable sustainable bio-feedstock, established supply chain
4. Technologies for CO_2 conversion to CO need to be fully proven at scale
5. Technologies for preparation and gasification of biomass/bio residue feedstock need to be fully proven at scale



Improvements in progress

6. Renewable power generation at scale and at low cost
7. Storage solutions (hydrogen storage, battery storage)
8. Direct Air Capture (DAC) technology development
9. Optimal integration of all building blocks (process and utilities), including offgas recycle

Shell Catalysts & Technologies

The Shell XTL Process for synthetic aviation fuel (e-SAF) and bio-SAF

SYNOVA

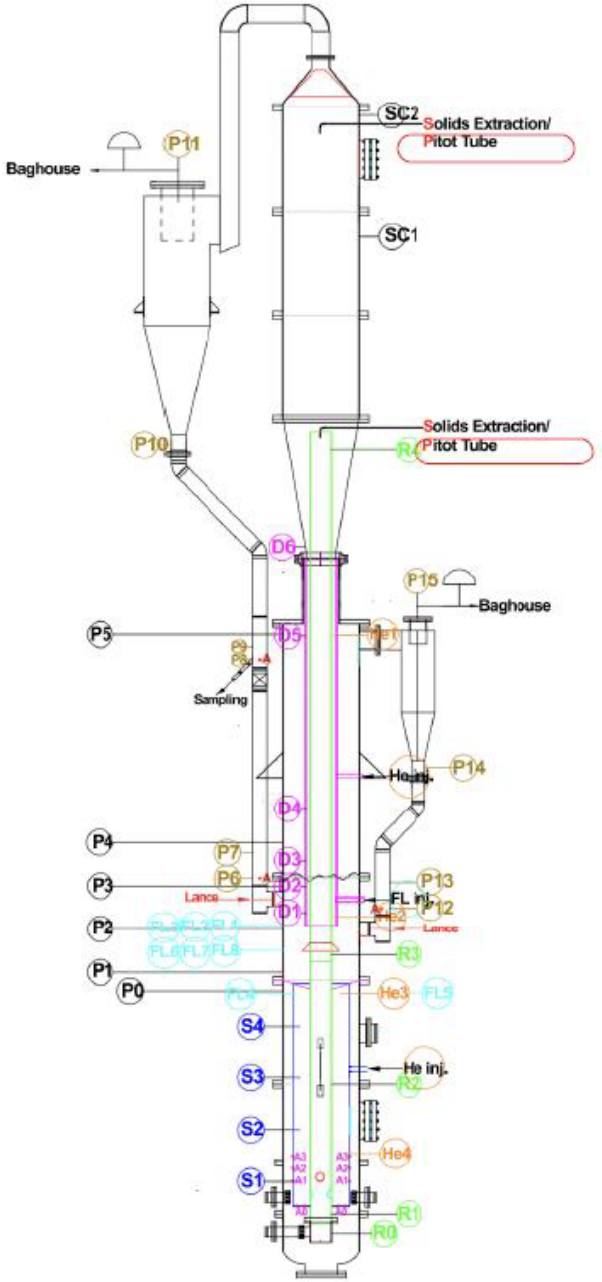
SYNOVA input for IEA Task33 meeting

May 2026

SYNOVA

Cold-Flow testing at PSRI (Chicago, US)

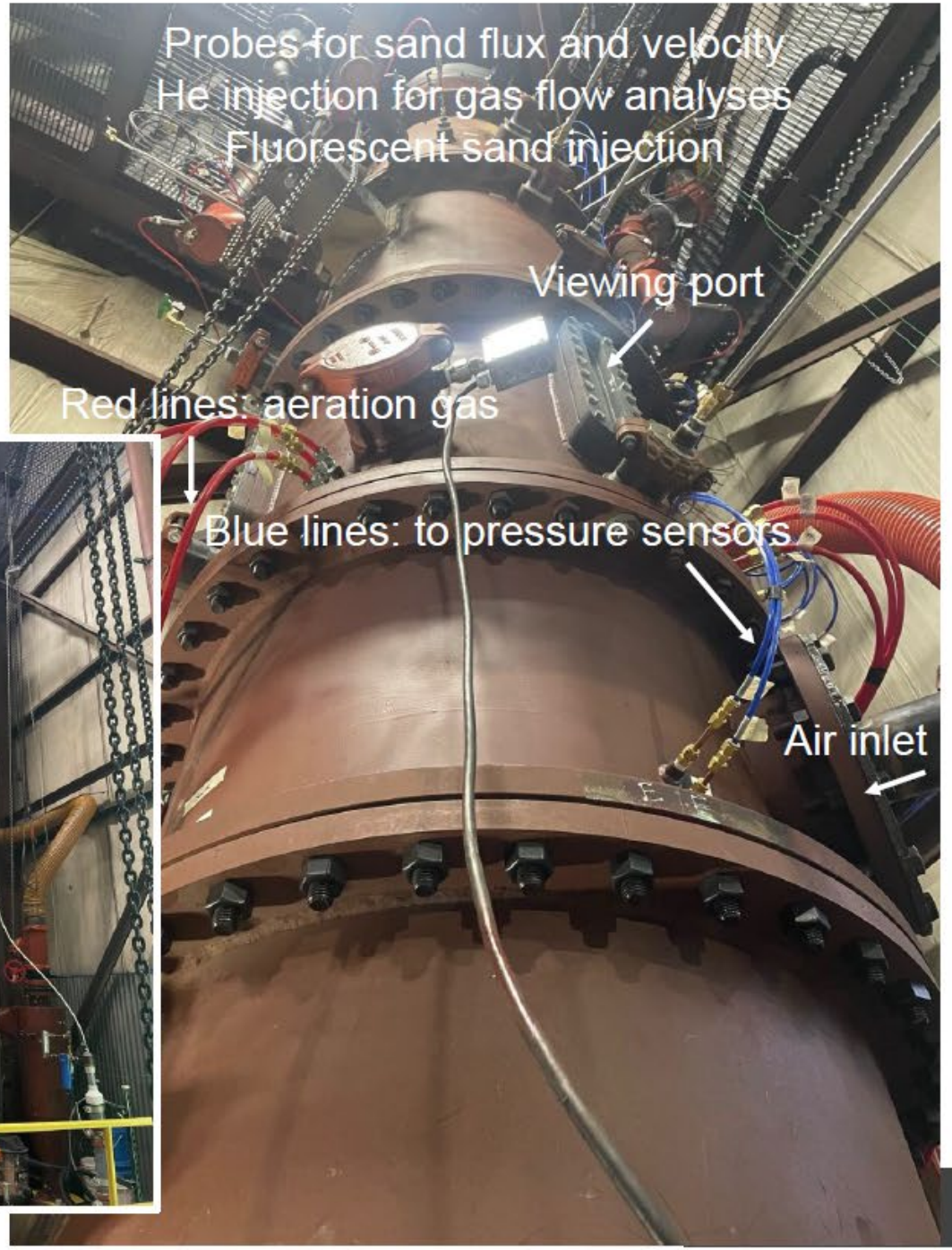
- SYNOVA clients require the solution to be scaled up, and like to confirm hydrodynamic behavior.
- SYNOVA decided to involve two reputable companies:
  - PSRI www.psri.org for cold flow tests
  - CPFD www.cpfd-software.com for fluidized bed modelling
- PSRI built a full-scale MILENA (full-scale height) in Chicago in 2025 based on 7 t/h MILENA design
- Tests are ongoing:
  - Pressure balances in the MILENA at various operating conditions
  - Sand flux (kg/m^{2}s) at different places and along radius of riser
  - Velocities of gas and sand at different places
  - Entrainment of sand out of the reactor
  - Checking for streaming flow
  - Visual access at various places in the system (viewing ports)
- So far, it works as expected!
- CPFD performed CFD (Computational Fluid Dynamics) calculations on the full-scale plant using Barracuda software



SYNOVA

Cold-Flow testing at PSRI

PSRI Particulate Solid Research, Inc.



DOPS

RECYCLING TECHNOLOGIES

Company Introduction

Resources | Energy | Security | **Circularity**

07-05-2026

www.dops-rt.com

Company Introduction

7-5-2026

Agenda

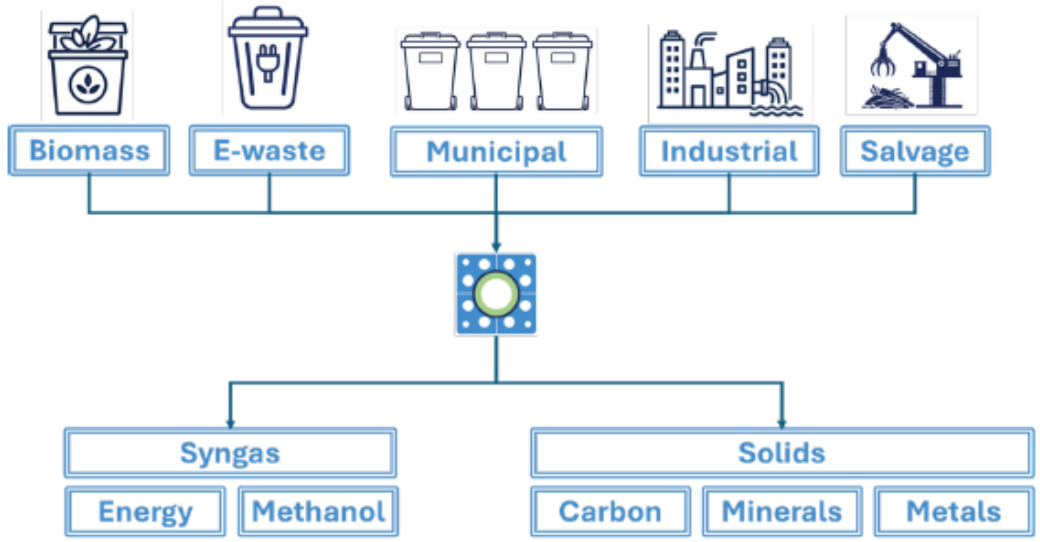
Introduction DOPS

DCI™ Technology

Timeline development

Mission of DOPS Recycling Technologies

"We believe in a clean and circular future. Our mission is to develop technology to convert waste into valuable materials, efficiently, sustainably, and profitably."



DOPS Recycling Technologies has developed and patented the Direct Carbon Immobilization (DCI™) technology.

DOPS RECYCLING TECHNOLOGIES

Agenda

- Introduction DOPS
- DCI™ Technology
- Timeline development

DCI™ Technology, multiple processes in a single reactor

In the solids shaft:

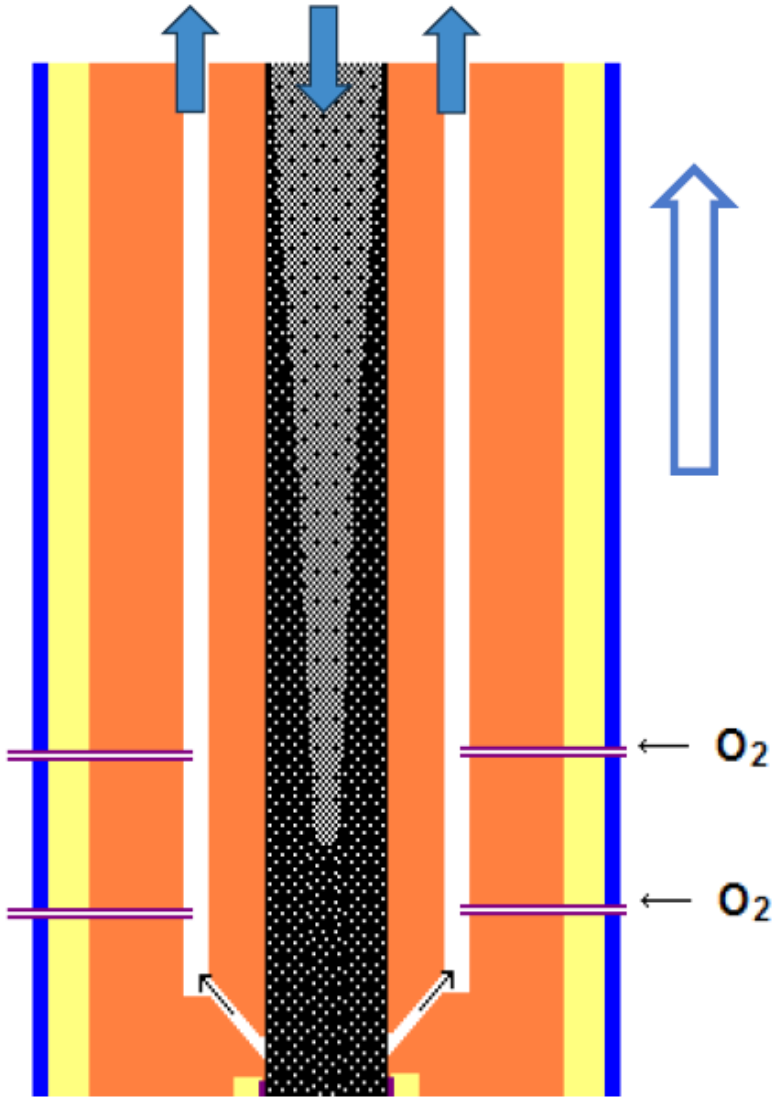
Torrefaction/ volatilisation

Depolymerization/ Pyrolization

Gasification / cracking of small molecules

Boudouard equilibrium: $CO_2 + C \Rightarrow 2CO$ at **1000 °C**

Filtration in moving carbon bed (soot captured!!)



In gas channels:

Chemical equilibrium Reverse watergas shift: $H2 + CO2 \Rightarrow H2O + CO$

Partial combustion by O_2 injection for energy balance and cracking of persistent molecules: (fluor-carbons, dioxins) up to **1500 °C**

DOPS RECYCLING TECHNOLOGIES

Agenda

Introduction DOPS

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DCI™ Target materials for conversion

All remnants containing hydrocarbons (chemical or natural):

- Mixed Municipal Waste;
- Biomass (dried, hard and soft);
- Paper waste (both from production and non-recyclables);
- Dried sewage sludge;
- Residues from mechanical recycling or pyrolysis heavy tars;
- (Crude) Oil and tank residues, asphalt, roof coverings;
- E-Waste;
- Batteries (EoL);
- Solar panels (EoL)
- Car deconstruction residues;
- Fiber reinforced plastics (windmill blades, aircraft components);
- Fluids or gasses to break down (with absorbing / carrier material).

Everything currently incinerated, land filled or composted.

DOPS RECYCLING TECHNOLOGIES

Agenda

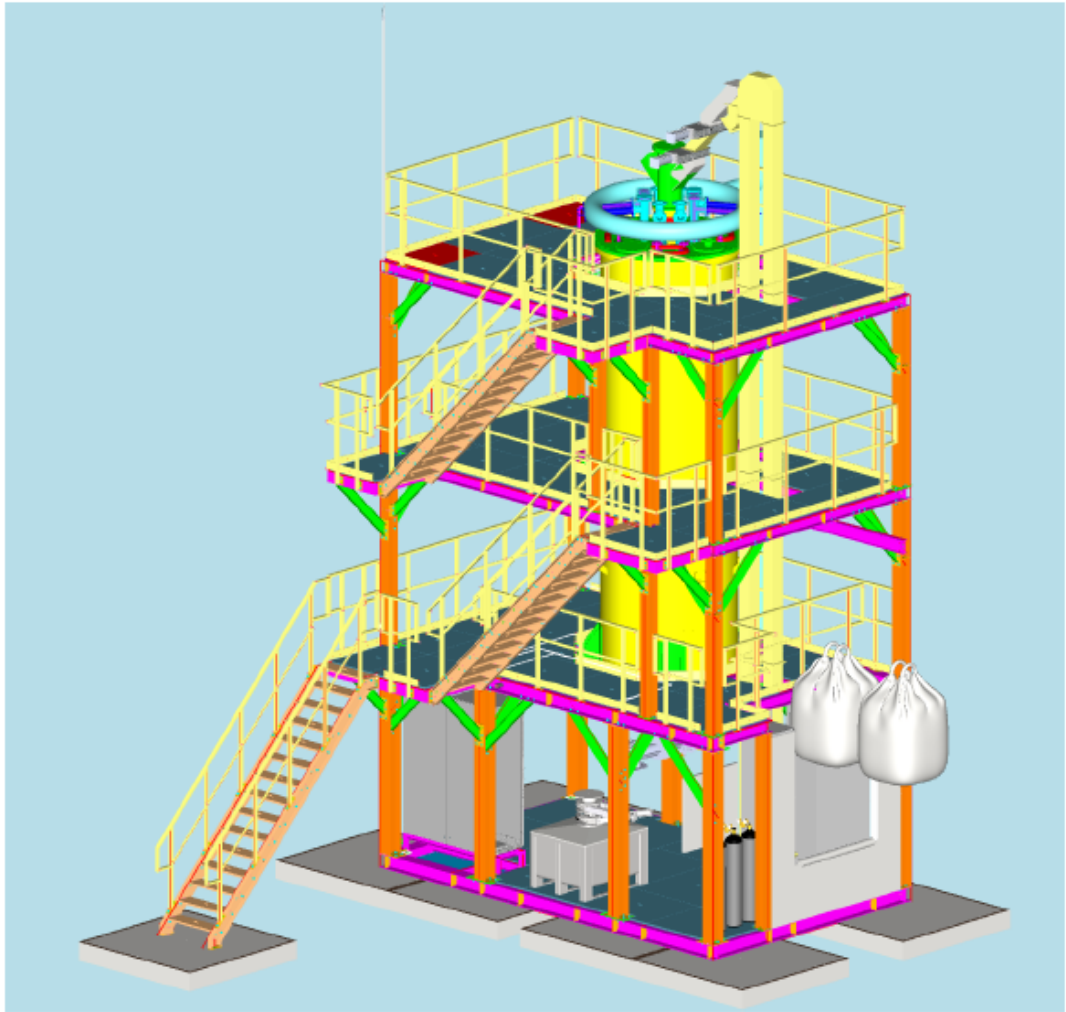
Introduction DOPS

DCI™ Technology

Timeline development

M-DCI 400

- Modular concept for capacity increase
- For all business domains available
- 1st Demo currently being constructed
- LOI for a 100 ktpa biomass to MeOH in Alkmaar, the Netherlands
- LOI for a commercial facility for confidential feedstock(4 units, several locations within EU)
- LOI for a commercial facility for replacement Natural Gas by Syngas(4 units within one facility)



DOPS RECYCLING TECHNOLOGIES

Company Introduction

7-5-2026

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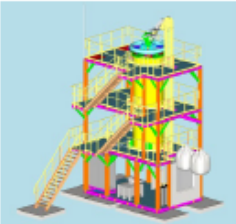
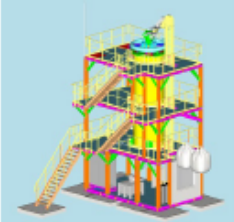
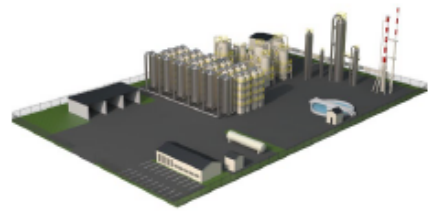
DCI™ development route by asset size

2022	2023	2024	2026	2028	2029
					
Size P.O.P. Cup tests	Size P.O.C. LSR 80 (DOPS)	Size P.O.C. LSR 100 (DOPS)	Size Demo M-DCI 400 (DOPS)	Size Commercial M-DCI 400 facility (Client)	Size Commercial DCI 600 facility (Client)
Process Everything	Process Waste Wood Repeat P.O.P. tests in small quantities	Process Make activated carbon process E-waste	Process Waste Wood + Complex waste	Process Confidential	Process Biomass To MeOH
Capacity 100 gr/batch	Capacity 4 kg/hr	Capacity 6 kg/hr	Capacity 100 kg/hr	Capacity 375 kg/hr	Capacity 11.000 kg/hr

P.O.P.: proof of principle
P.O.C.: proof of concept

achieved | scheduled

DOPS RECYCLING TECHNOLOGIES

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IEA Bioenergy
Technology Collaboration Programme

www.ieabioenergy.com